

*Thursday afternoon*

ANALYSIS OF THE SUBJECT-MACHINE RELATIONSHIP

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## Overview

An apparent phenomenon which defies the theory of probability occurs when Subject 2 plays this experimental game. He significantly exceeds his probability of success, .25, by scoring over .29. The question that this report addresses is: Is there a statistical or logical reason why he did so well? The methodology used to attack this problem and the resulting conclusions are summarized below. This summary can also serve as an outline to this detailed report.

### I. Statistical Analysis of the Machine Experimental Data

Pre-experiment data analysis discovered a non-random characteristic through the examination of forward-backward state transitions (i.e., Red-Blue, Blue-Red). However, the coefficient of correlation between the forward and backward states of .58 for the experimental data, .49 for Machine 1 data and .48 for Machine 2 data were considered low enough that this approach was dropped. Pre-experiment state transitions had a coefficient of correlation of .93.

The experimental data randomness analysis consisted of examining the distribution of color totals and the distribution of each color taken over various combinations and permutations of the data. No evidence of non-randomness was discovered.

### II. Analysis of the Subjects' Data Responses

The subject's responses were analyzed with the emphasis on the discovery of his strategy or the unveiling of a trend which would give him a statistical advantage. The possibilities investigated produces no solid reason how he was able to be so successful. However, in one case there is a strong indication why he was able to succeed. It appears that he was learning the states of Machine 2. The details of this are in

the remainder of the report.

### Miscellaneous

The report contains a section entitled "Miscellaneous" for the purpose of displaying detailed data which wasn't directly required by the above more general analysis. Details such as how many successful choices in the color red during the 50th trial were there, or what was the relationship of the number of passes to the number of successes.

The terminology used is as follows: the term "trial" refers to the string of machine states and corresponding choices from the time the subject begins until he makes 25 non-passing choices. A sample is a machine state and/or subject choice (including passes). There are  $(25 + \# \text{ passes/trial})$  samples in each trial.

## I. Statistical Analysis of the Machine Experimental Data

SG11

## Forward-backward State Transition Analysis

In a previous memorandum (Memo ORD 2240-75, 12 June 1975 to ) the question of randomness with the emphasis on state transitions as an indication of non-randomness was addressed. The data used in the investigation consisted of pre-experiment trials. The purpose of this section is to do a similar investigation using the actual data which occurred during S2's experiment.

Table 1 presents all possible transition frequencies. All transitions should have equal probability.

	YELLOW	GREEN	BLUE	RED
YELLOW	204	199	199	216
GREEN	192	218	222	207
BLUE	211	206	228	222
RED	209	206	223	221

Restructuring into a two-by-six table as in Ref 1 produces:

	Y/G	Y/B	Y/R	G/B	G/R	B/R
FORWARD	199	199	216	222	207	222
BACKWARD	192	211	209	206	206	223

The conclusion based on pre-experimental data was that these state-pairs show a very strong relationship between forward and backward transition frequencies (coefficient of correlation = .93). However, computing the coefficient of correlation,  $p_{S2}$  actual data = .58, it becomes apparent that the degree of dependence is slightly reduced. Therefore the dependence of forward to backward states can no longer be considered as a strong indicator of non-randomness.

The data used in the above discussion consisted of trials from both machine 1 and machine 2. Since non-randomness, made apparent by the state transitions, clearly existed for pre-experimental data, the investigation of the experimental data continued to include a search for this trend in the individual machines. The transitions (including identity) are as follows:

Machine 1

	YELLOW	GREEN	BLUE	RED
YELLOW	96	79	88	92
GREEN	85	87	86	88
BLUE	85	82	90	87
RED	91	91	83	92

Machine 2

	YELLOW	GREEN	BLUE	RED
YELLOW	108	120	111	124
GREEN	107	131	136	119
BLUE	126	124	138	135
RED	118	115	140	129

Computing the two coefficients of correlation,

$$\rho_{\text{machine 1 s2 data}} = .4934$$

and

$$\rho_{\text{machine 2 s2 data}} = .4838$$

it is obvious that the forward and backward transitions are even less dependent than in the combined case. Thus ended the search for non-randomness through state transition.



As a by-product the following table is produced for general information.

	BOTH MACHINES		MACHINE 1		MACHINE 2	
	MEAN	SD	MEAN	SD	MEAN	SD
FORWARD	210.8	10.7	86.6	4.27	124	9.74
BACKWARD	207.8	9.00	86.2	3.92	121	11.25
TOTAL DATA POINTS	3483		1446		2037	
COEFF OF COV	.5843		.4934		.4838	

3191  
2702  
3650

## Experimental Data Randomness Analysis

The machine data used during the S2 experiment has been combined, summarized and/or permuted in an attempt to establish evidence of randomness or non-randomness. If an obvious indication of non-randomness would have evolved this task would be simplified because it would have become a closed form problem (i.e., the solution would be - the data has non-random characteristics). *needed investigator*  
However, what has resulted is that various forms of the data have been examined with all indicating that the data is random.

Tables, plots and commentary are presented in this section to demonstrate randomness and in some cases just to provide general information concerning the machines data.

The distribution of the colors collectively and for each machine is as follows:

	Yellow	Green	Blue	Red	Total	Mean
Machine 1	365	353	356	372	1446	361.5
Machine 2	475	505	538	519	2037	509.25
TOTAL	840	858	891	891	3483	870.75

Machine 1 was not used in as many trials as machine 2 (44 trials to 56 for machine 2), thus the difference in totals. The standard deviation of binomial distribution with  $n=3483$  and  $p=1/4$  is 25.56 which would imply that each separate number is reasonably close to the mean.

Accepting the distribution of the totals consider the distribution of the colors throughout the experiment. The populations used for this investigation consisted of the first 25 samples of each trial (100 trials total). This population is acceptable since the distribution of its totals was reasonable and since the performance of S2 was approximately the same (success-29.61%) for this subset.

The following three approaches comprise the strategy used to attack the question of color distribution.

1. Each trial (abbreviated to 25 samples) as analyzed separate interval.  
Obviously this will indicate any bias within each trial.
2. The data (2500 samples) is divided into intervals of five samples each. This will indicate unusual repetitions either within the interval or interval-by-interval.
3. The data is reformatted into 25 intervals of 100 samples, where the nth interval consists of the nth sample in each trial.

The results of approach 1 is shown in Figures 1.1.a, 1.1.b, 1.1.c, and 1.1.d.

The binomial distribution for this strategy ( $n=25$   $p=1/4$ ) is mean 6.25 and the variance 4.69. The plots indicate randomness throughout the 100 trials.

The results of approach 2 are similar to approach 1 and are shown in the four tables in Figure 1.2. The plots indicated randomness but are not shown because of monotony. The binomial distribution mean is 1.25 and the variance .94.

The binomial distribution mean and variance for approach 3 is 25 and 18.75 respectively (Figure 1.3). A plot of the data (Figure 1.4) for the "RED" case because of the concern for the higher variance and ranges. The 13th sample seems to have an unusually high frequency of "RED" (44%). However in general this investigation has not produced a significant non-random characteristic.

sample size	100
maximum	12
minimum	3
range	9
mean	6.23
variance	4.239494949
standard deviation	2.059003387
mean deviation	1.6314
median	6
mode	6

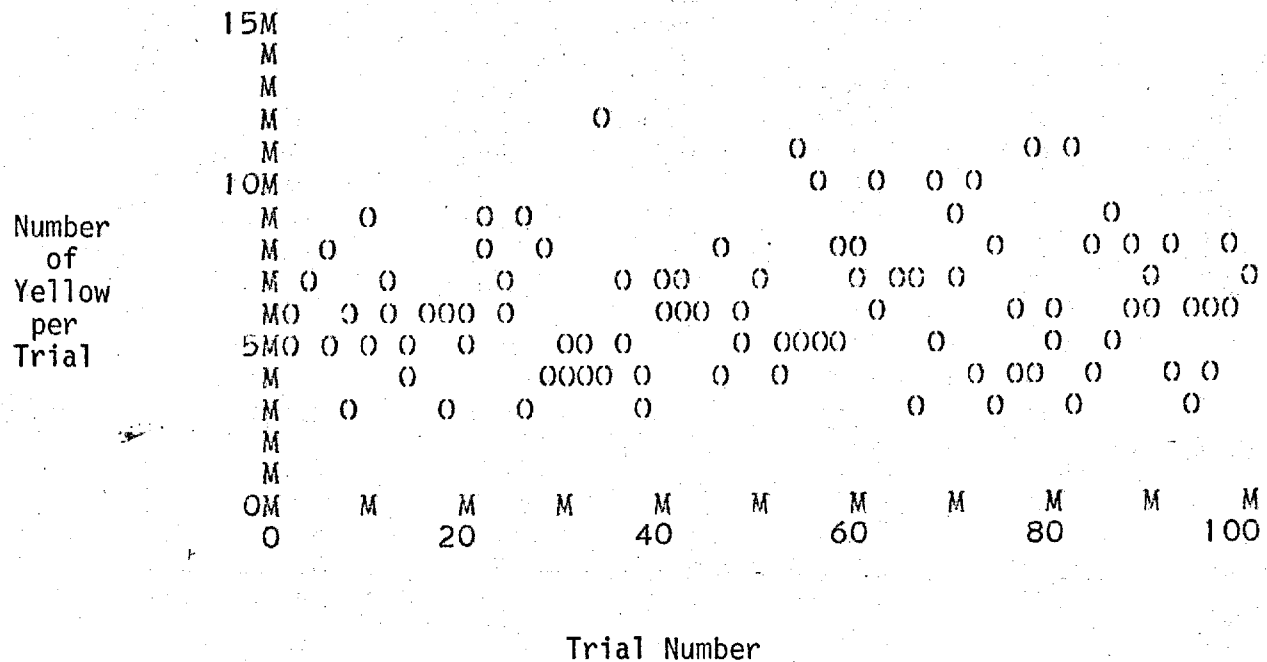


Figure 1.1.a Distribution of Machine Yellows Over Trials

sample size	100
maximum	12
minimum	0
range	12
mean	6.13
variance	5.851616162
standard deviation	2.419011402
mean deviation	1.9404
median	6
mode	5 7

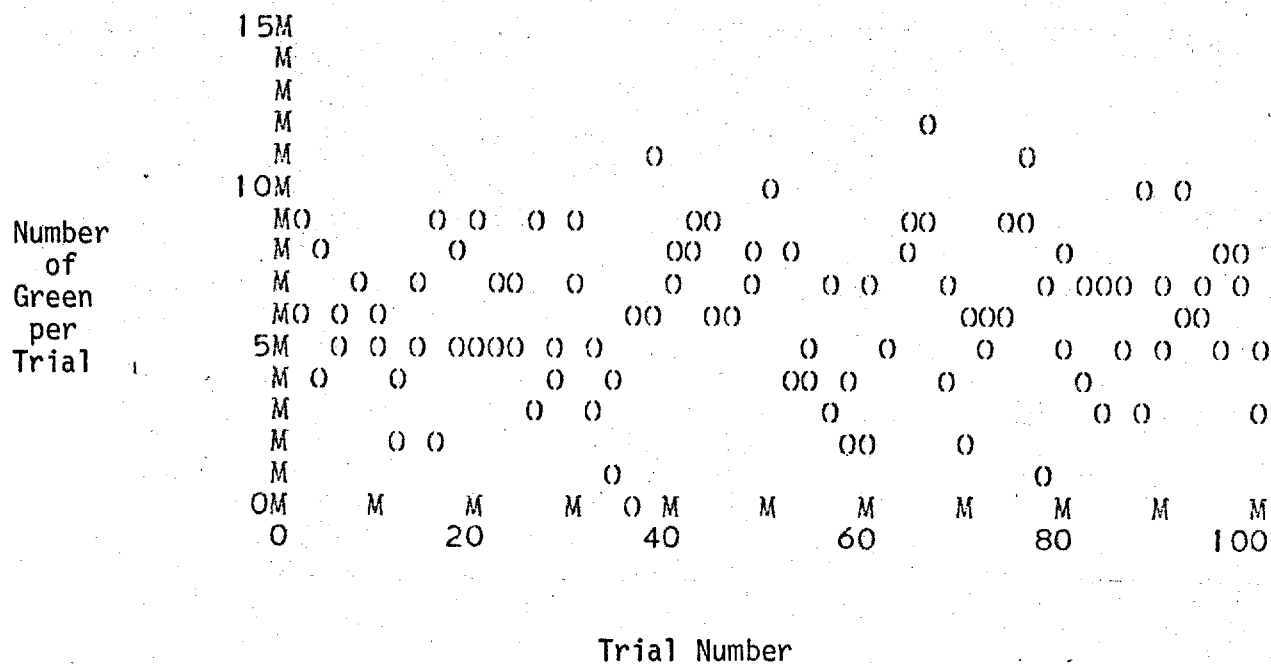
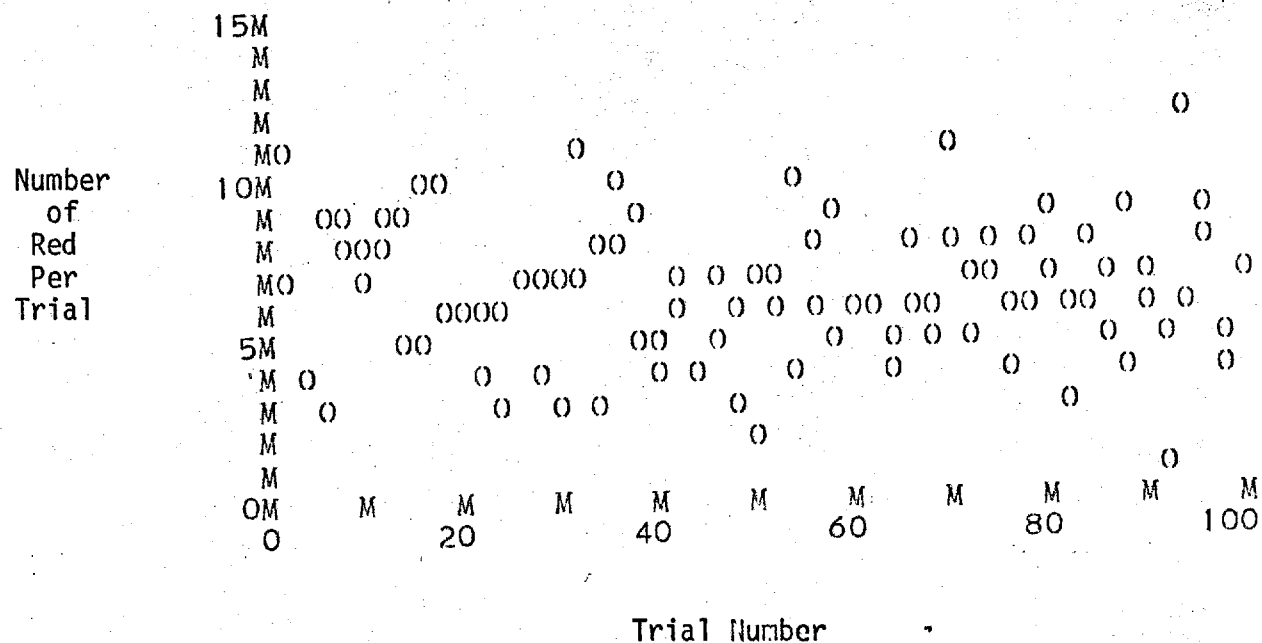


Figure 1.1.b Distribution of Machine Greens Over Trials

Number of Blue Per Trial

Trial Number

sample size	100
maximum	12
minimum	1
range	11
mean	6.43
variance	4.631414141
standard deviation	2.152072058
mean deviation	1.7158
median	6
mode	6



sample size	500
maximum	5
minimum	0
range	5
mean	1.246
variance	0.9594028056
standard deviation	0.9794910952
mean deviation	0.784848
median	1
mode	1

#### Distribution of Green

sample size	500
maximum	5
minimum	0
range	5
mean	1.226
variance	0.9969178357
standard deviation	0.9984577285
mean deviation	0.804512
median	1
mode	1

#### Distribution of Blue

dstat grp: <3:

sample size	500
maximum	4
minimum	0
range	4
mean	1.242
variance	0.9513507014
standard deviation	0.9753507014
mean deviation	0.792192
median	1
mode	1

#### Distribution of Red

sample size	500
maximum	5
minimum	0
range	5
mean	1.286
variance	1.026256513
standard deviation	1.013043194
mean deviation	0.823216
median	1
mode	1

Figure 1.2 Distribution of M... at a Time



Yellow Distribution  
sample size 25  
maximum 31  
minimum 19  
range 12  
mean 24.92  
variance 10.57666667  
standard deviation 3.252178757  
mean deviation 2.6304  
median 24  
mode 24

Green Distribution  
sample size 25  
maximum 35  
minimum 15  
range 20  
mean 24.52  
variance 24.59333333  
standard deviation 4.959166597  
mean deviation 3.9392  
median 25  
mode 22 25

Blue Distribution  
sample size 25  
maximum 34  
minimum 19  
range 15  
mean 24.84  
variance 14.47333333  
standard deviation 3.804383437  
mean deviation 2.9664  
median 25  
mode 26

Red Distribution  
sample size 25  
maximum 44  
minimum 16  
range 28  
mean 25.72  
variance 26.71  
standard deviation 5.168171824  
mean deviation 3.3664  
median 25  
mode 25

Figure 1.3 Distribution of Machine Colors When Samples are Taken 100 at a Time  
(One From Each Trial)

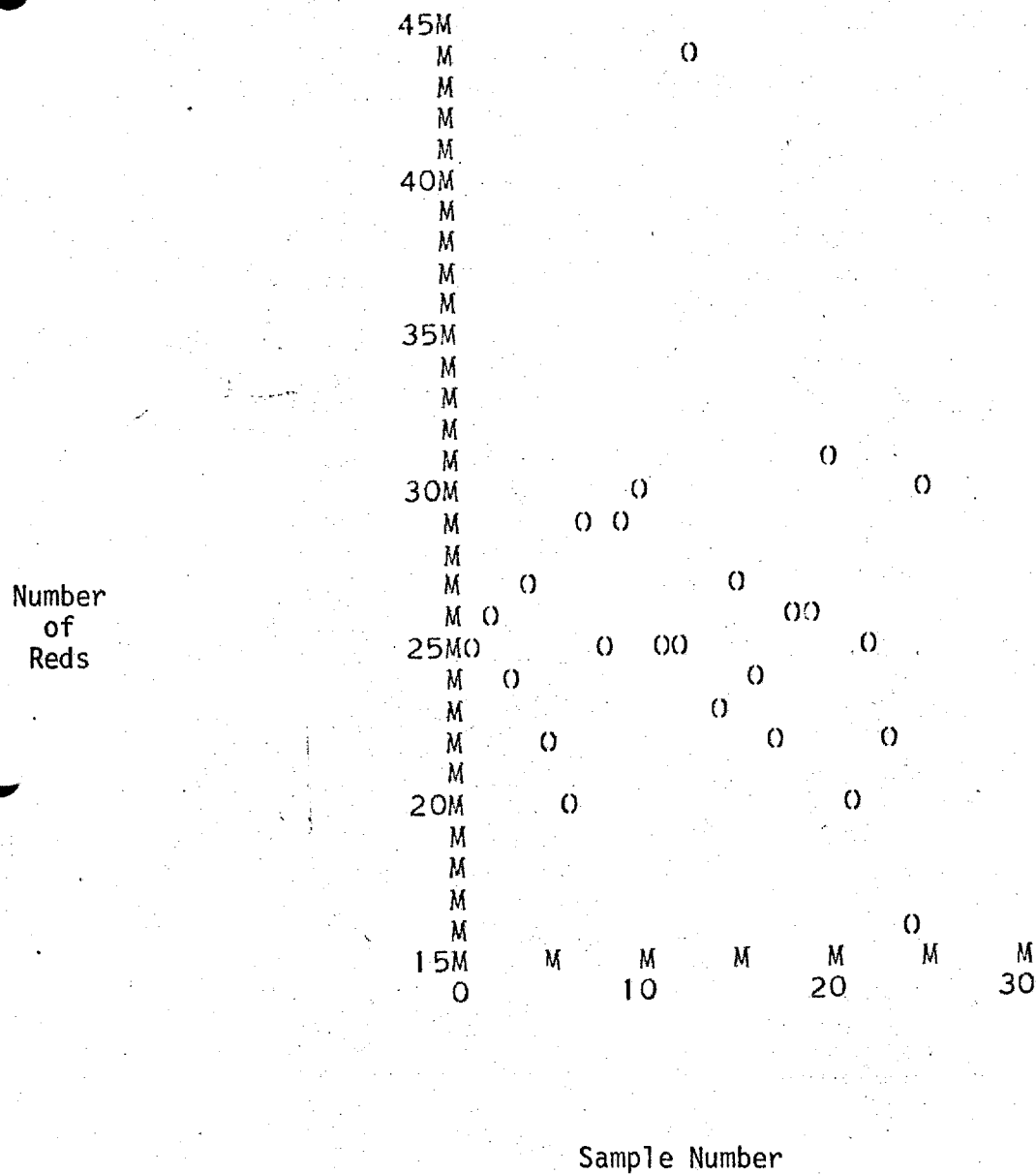


Figure 1.4 Distribution of Machine "Reds" when the Samples are taken 100 at a time (one from each trial)

Approach 1 has been repeated for Machine 1 and Machine 2 separately to check for abnormalities. The binomial distribution mean and variance are as follows:

	Trials	Mean	Variance
Machine 1	44	11	8.25
Machine 2	56	14	10.5

## Machine 1

## Yellow

sample size	25
maximum	16
minimum	7
range	9
mean	11.4
variance	7.75
standard deviation	2.783882181
mean deviation	2.224
median	12
mode	12

## Machine 2

sample size	25
maximum	19
minimum	7
range	12
mean	13.52
variance	7.51
standard deviation	2.740437921
mean deviation	2.176
median	14
mode	15

## Green

sample size	25
maximum	17
minimum	4
range	13
mean	10.68
variance	9.726666667
standard deviation	3.118760438
mean deviation	2.3584
median	11
mode	11

sample size	25
maximum	24
minimum	8
range	16
mean	13.84
variance	12.72333333
standard deviation	3.56697818
mean deviation	2.7808
median	13
mode	13

## Blue

sample size	25
maximum	15
minimum	3
range	12
mean	10.32
variance	7.726666667
standard deviation	2.779688232
mean deviation	2.3072
median	11
mode	8 12

sample size	25
maximum	25
minimum	10
range	15
mean	14.12
variance	8.943333333
standard deviation	2.990540642
mean deviation	1.984
median	14
mode	15

## Red

sample size	25
maximum	19
minimum	4
range	15
mean	11.6
variance	10.5
standard deviation	3.240370349
mean deviation	2.4
median	12
mode	12

sample size	25
maximum	21
minimum	11
range	10
mean	14.52
variance	10.01
standard deviation	3.163858404
mean deviation	2.6624
median	13
mode	11 13

Best Strategy

Based on the above analysis what is the best strategy to pursue? No good strategy is available based on the randomness of the data. The best possible strategy based on the above transition matrices is:

1. If the subject can't distinguish between machine then press blue when blue appears, else pass.
2. If the subject can distinguish them on Machine 1, press yellow when yellow occurs, and on Machine 2 press blue when red occurs.

For all its worth, of the existing data the following success would result - 26%, 26%, and 27%.

## Analysis of S2 Data Responses

The attempt here is to discover a reason for S2's success at responding. The investigation was unable to give a definitive reason for his success. Although no strategies were uncovered there was in one case a indication that the subject was learning.

Two major approaches have been taken in this investigation. They are as follows:

1. Strategy of S2 - Was there any trends in the way he guessed? Did he respond based on the previous state of the machine? *There is two guesses*
2. Hit analysis - Did the subjects' hits (correct choices) increase within a run; did it increase from run to run (i.e., was he learning?)

## Strategy of S2

For general information and future reference the first figure (Figure 2.1) presented is the actual choices. One item of curiosity from this is that when he passes, he tends to do it in strings. This characteristic of course wasn't pursued because of its insignificance to this report; however, observations like that are pointed out throughout the report as possible importance to those in the field.

## Total Color Choices

The distribution of S2's color choice totals are shown below.

0210232010213003020300330  
 0203121303030330000102332  
 3003103030312032103222123  
 0233310020320130300020313  
 3030030010303031313030103  
 3303031303030003202103103  
 0323030303020301032030330  
 0320303030302103030301303  
 0303032022303010313021020  
 3010103103013303013023013  
 0313023313303102013103231  
 0210310310310332031030230  
 3030203103030130130303023  
 3030323013030203010330303  
 3030030302303130313031300  
 3023130302102313010130203  
 303070307300103077230770731377030773  
 320301303077307070130303723770373  
 03023010737037737301730307177707207370  
 021303077730702302303070723730703  
 03701037777321033700371307077301031  
 0777377730777317077377037233103273073030373  
 373031377773073277307707307707073007077773203  
 307370307302130313313777073023777377770  
 03031700120120313027772323103  
 0131320203120310773071730777772031  
 30373030377730301307307770330377777773070  
 31217033030130037777771300012003  
 002730770377277777310777377777377777773132133013070  
 3173777777777777170710777777730137777073703132777777030777737013  
 377770777701777777770307373177777303031031031020  
 377172707777013071737177773777777777702030317013201  
 037777777777377010377777707770777777773013131303230320  
 00230713013077777777777713013023201303  
 077777701010203010230703730270730777777713  
 30713777037077703777773231077777777777777031307777777777777773703703771  
 302077771303703130313021037013777777777777770  
 31037321013013102310370107731  
 31313023130132013023730177703  
 1303737373013013207777737777777707313021071  
 13731037373173021772731771317777777703733170  
 13237013077072313103127773713173777373  
 31377777777777737770331310213717777717077731727120713  
 01237073773177731737201720307072170130  
 073373113701310701077201377032770070  
 321317032331303203723032123  
 137370710303107720311307100323773  
 10307710237371307307230233203730  
 2030330231313302212121331  
 23077701273212000303333130300

Figure 2.1 Subject 2 Color Choices for First Fifty Trials (0-yellow, 1-green,  
2-blue, 3-red, 7-pass)

20703123070231703030330133703  
30170102031730730300330313713  
01007777373707303777173777273377310770777130777373773  
207073707317773700770373700027317770707777707377777377773  
01730330320370330327013703013  
303717033207303073773013023737203  
0373737303373032173233377173733707371  
23707377313033333703773773707173777377373270  
13107303737730103333370737313707700  
33373707730730373333130373370707770733  
033037737703337337777077777327777301027337333  
030303720000377373377707737733030332  
33032133270323233130121330  
10701101301101313030230123  
300703300723730030371777137777033002  
0313373737030003200030001003  
302332131000001371303703037770  
77201771007703072370313731013777377177777303  
337171017711371300217333733030733  
30717373717077130117303707301373370071  
03303203020071027107377121270703  
03231327320373023770331110077700  
33173707371071317331331730117207073  
271313107327033277731177130323303  
3000373300033003710303071330  
301270013333013077737077373303377770770  
0303703037073732311370710732001773  
37733070072000770300373130003002  
132002000300303770300731723370  
30707207020773307033030303777377737377073  
0707773070370037777770773170733030730707770737373  
007077373770030737307777777073777773777377030007773333  
1301037132010717301002720073723  
3101310317001300001730073020  
03777720070773100770707373007200730700700  
30300007100000232113002002  
3031301301320130231033003  
2301203130120310311303120  
3013023103173713073032300131  
3013013013201302101302303  
130231032303713273031030130  
3010310310773230313073021331  
310313031737701373001330033777713  
31301030310330307377070037717003  
023130332013700137230201330  
0217373103101303700073027777310373  
137073107103702373132710331073703  
331300301707301070700371073700713

Figure 2.1 (Continued) S2 Color Choices for Last 50 Trials



	Yellow	Green	Blue	Red
Total Times Chosen	881	411	237	971
% of Total	35%	16.5%	9.5%	39%

The first inclination is to try and determine how his strategy of choosing so many yellows and reds benefitted him. Examine the following table:

	Yellow	Green	Blue	Red
Total Number of Hits	255	127	<del>50</del> <sup>60</sup>	292
% of Total Hits	35%	17%	8%	40%
% of Success in Color	29%	31%	25%	30%
(Hits - Correct Choices)				

As can be seen his results with blue are significantly lower than the others. However, assuming the probability of success to be .25 and using the binomial distribution the expected value = 69 and the standard deviation = 7. The inference from this is that the 60 Blue hits are not a statistical abnormality. However, it is curious that he did so much worse on his lowest preference.

#### State Transition Color Choice

This investigation consists of examining the states of the machine verses the choice on the next sample of the subject (i.e., if the machine shows "red" does the subject consistently choose one color on the next turn). Consider the following table:

SUBJECT	MACH \ SUBS	Machine				Pass	% Pass
		Yellow	Green	Blue	Red		
SUBJECT	Yellow	106	119	69	314	210	26%
	Green	177	25	69	316	252	30%
	Blue	241	99	27	198	302	35%
	Red	322	157	65	97	218	25%

$r = .30$

The subject obviously avoids repeats (i.e., he assumes the machine won't repeat a color) which, based on the machine data analysis, isn't a strategy which would give him a statistical advantage. Previous analysis showed that identity transitions are approximately equally probable as nonidentity. Notice also that he passes 35% of the time after seeing a blue.

The same state transitions are shown below separated by machine.

		Yellow	Green	Blue	Red	Pass
M A C H I N E 1	Yellow	48	49	25	150	83
	Green	62	13	35	153	83
	Blue	105	36	10	78	115
	Red	133	72	30	58	64
			$\psi = .94$	$\updownarrow$		
M A C H I N E 2	Yellow	58	70	44	164	127
	Green	115	12	34	163	169
	Blue	136	63	17	120	187
	Red	189	85	35	39	154

The negative state transition (i.e., relationship of the subject color choice to the machine state on the next sample) is considered too bizarre of a concept to be presented in this section. Results of that investigation is found in the section entitled "miscellaneous"

### Hit Analysis

This section is significantly more important than the randomization analysis of the machine data. The reason is that if he is not learning from the machine or he is not taking advantage of biases then the discovery of such non-randomness is of little value to the overall analysis.

### Learning from Trial to Trial

The question of whether the subject learned from trial to trial can best be answered by examining the following three plots. The first is the number of hits vs. the trial number, the second is a frequency distribution of the number of trials vs. number of hits, the third is the accumulated probability vs. the trial number.

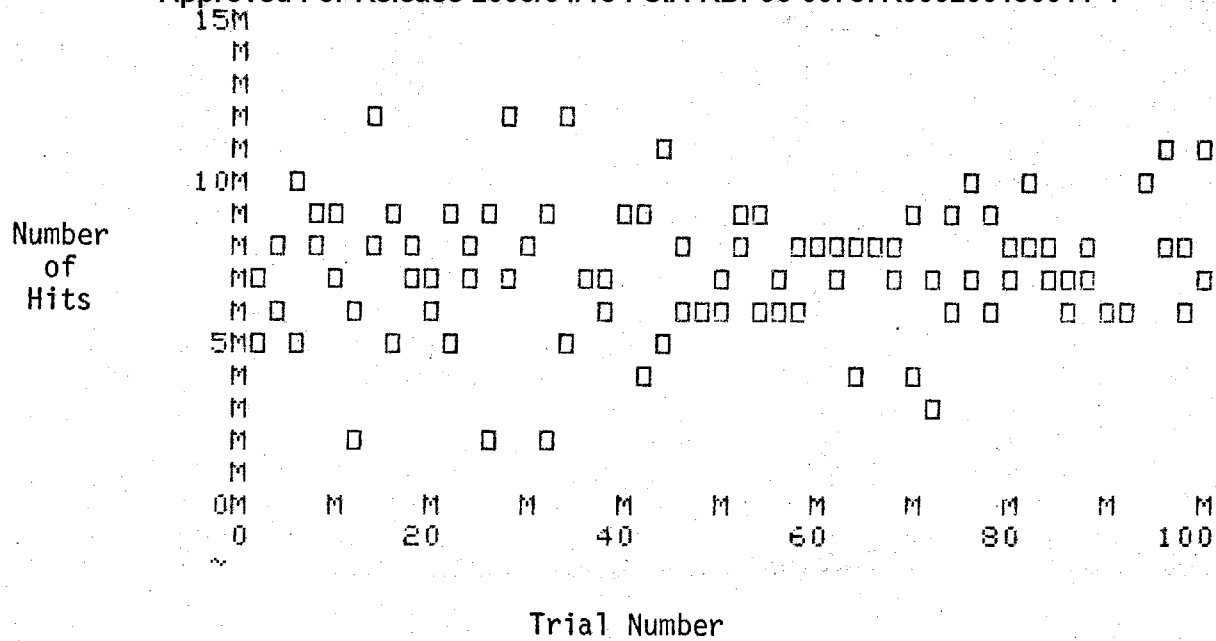


Figure 2.2 Plot of number of hits/trial

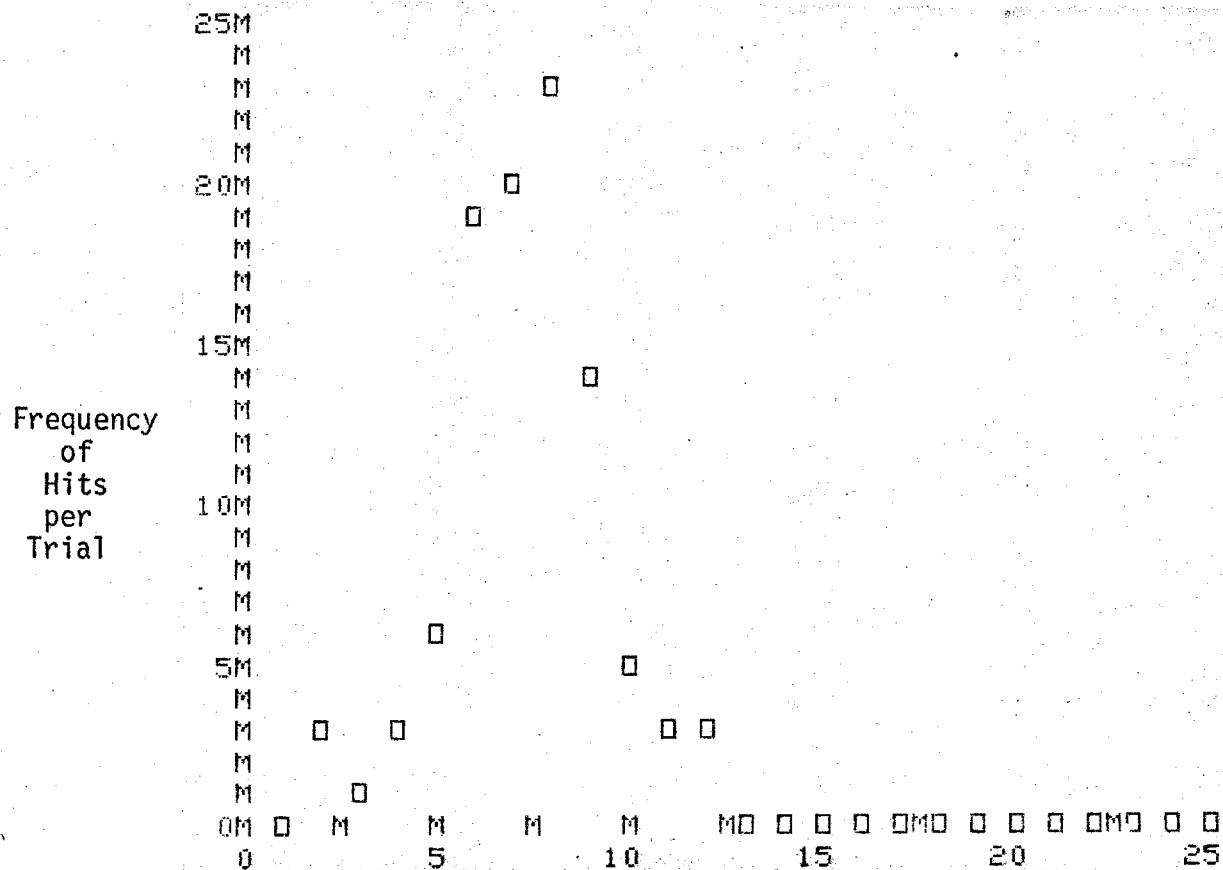


Figure 2.3 Frequency plot of Number of Hits

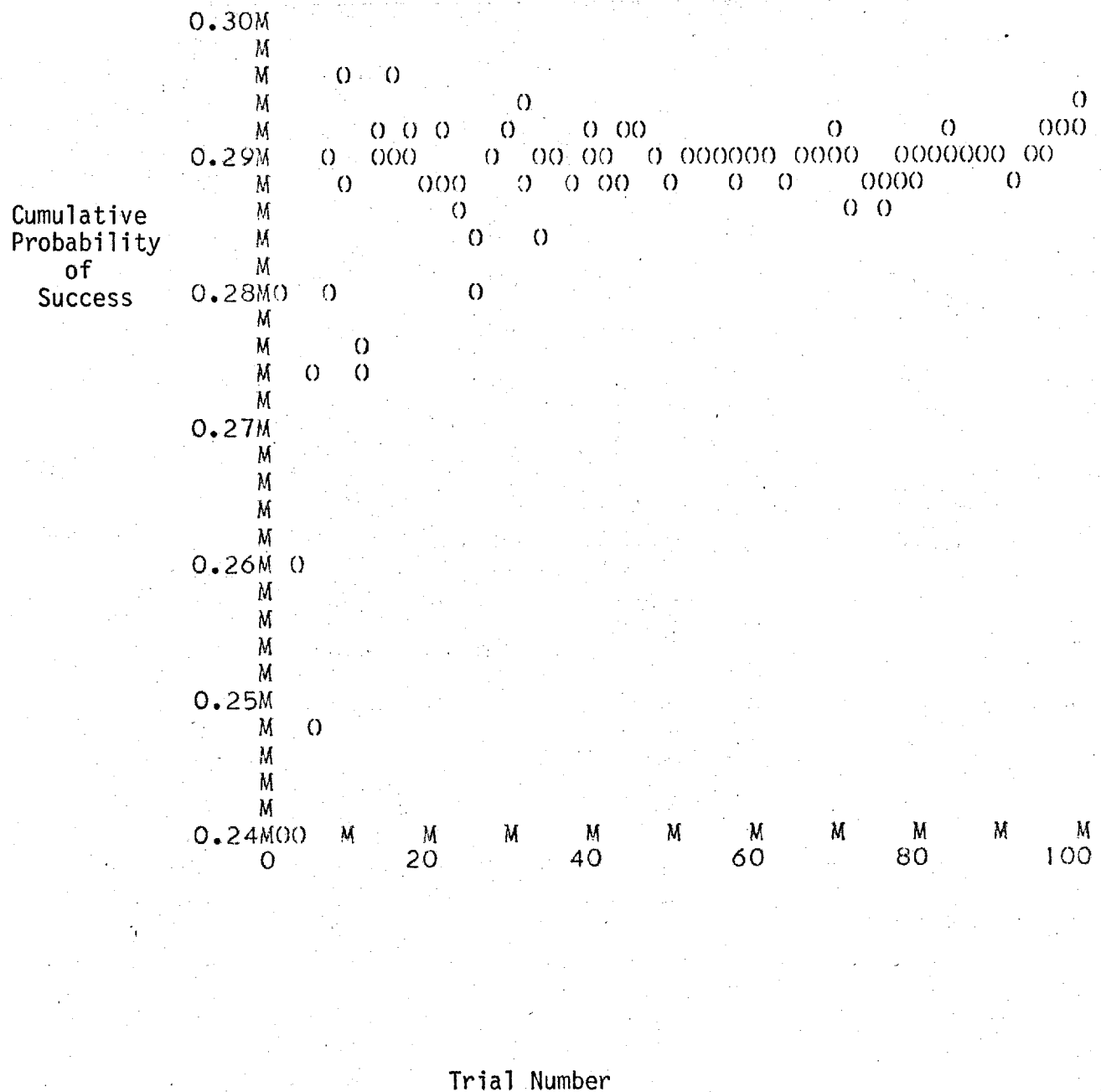


Figure 2.4 Cumulative Success Ratio of Subject (both machines used)

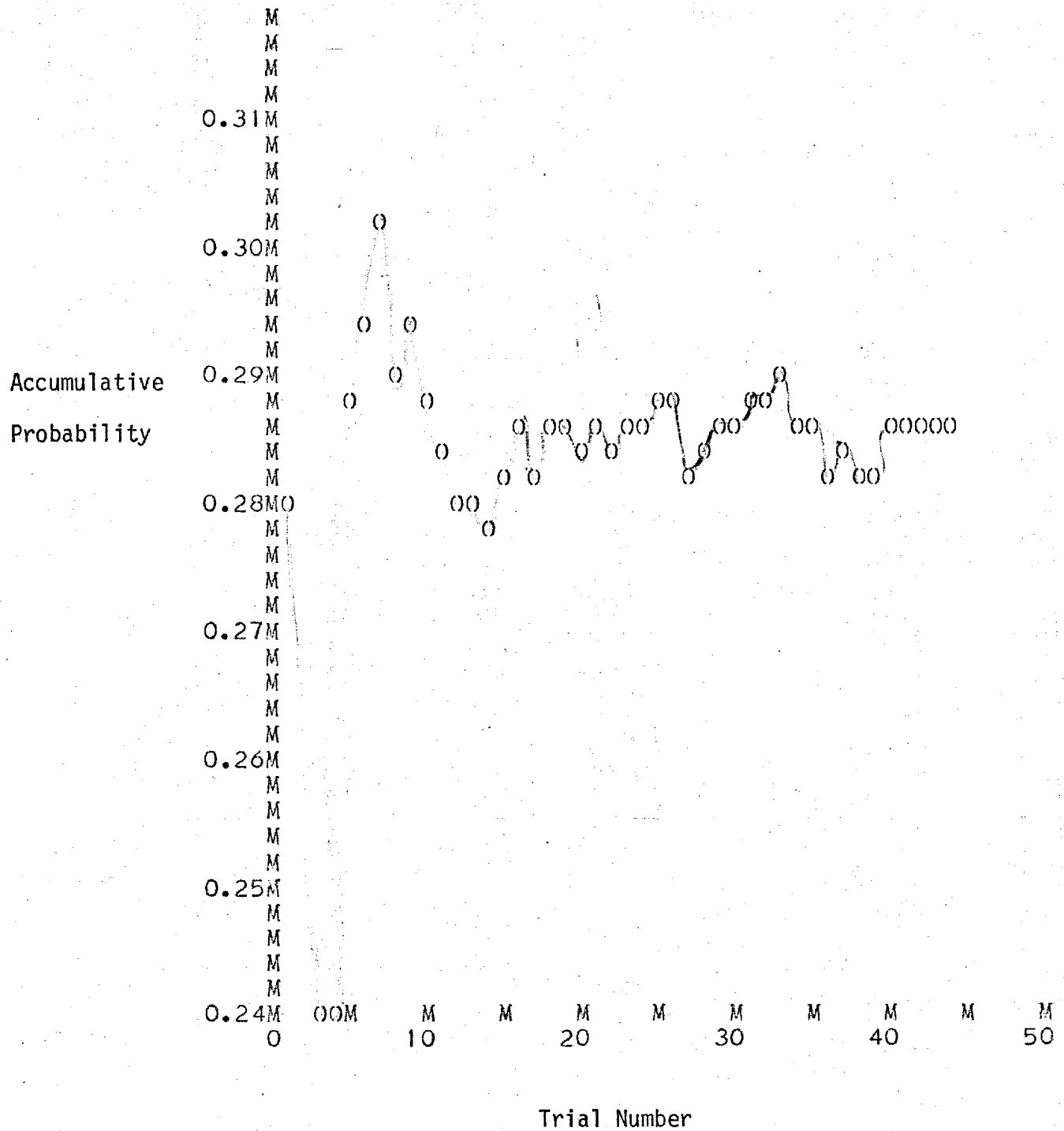
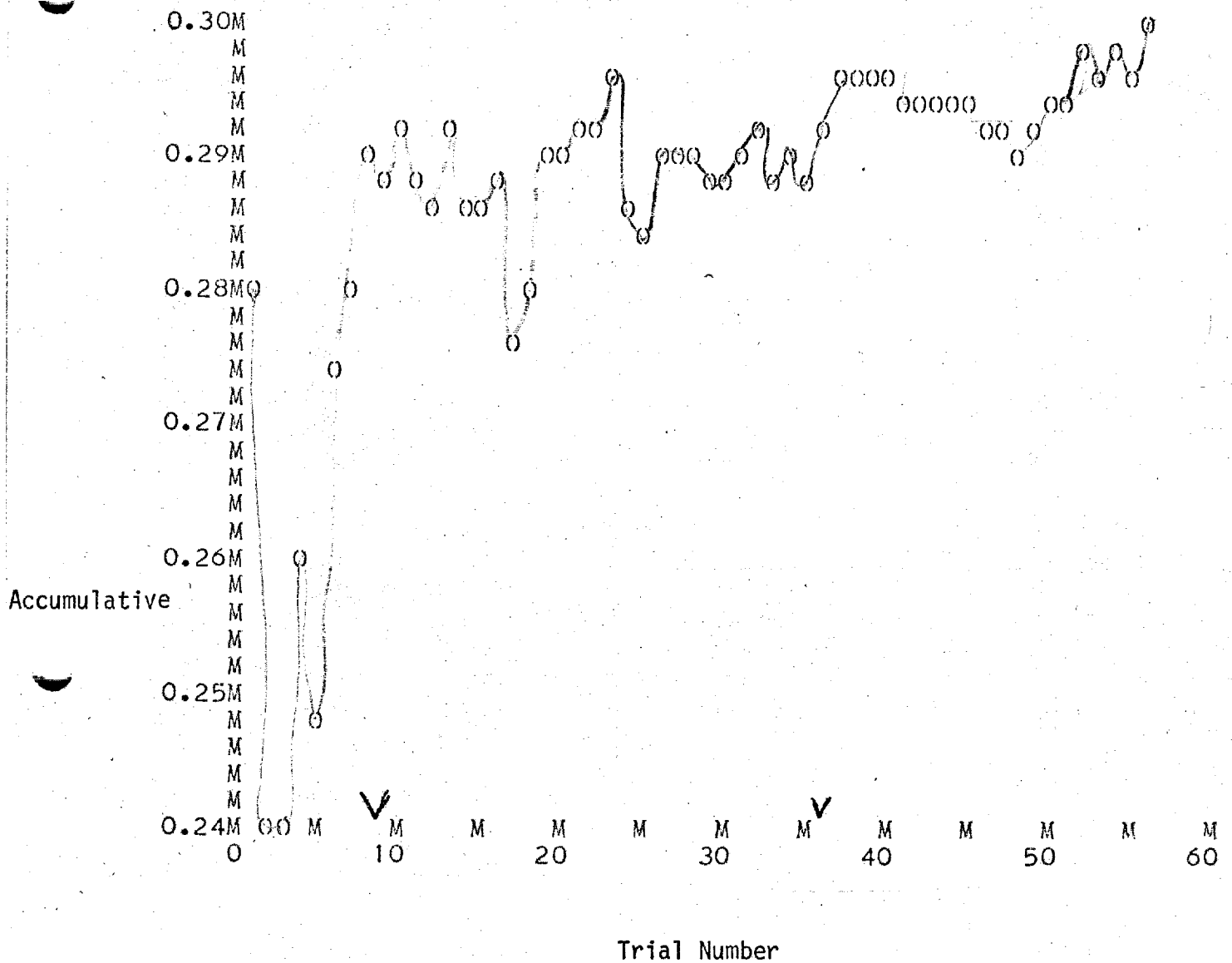


Figure 2.5 Accumulative Probability of Success on Machine 1



Note: V - Points at which he switches machines

Figure 2.6 Accumulative Probability of Success on Machine 2

The first plot (Figure 2.2) demonstrates the randomness of the number of hits while the second plot (Figure 2.3) demonstrates the frequency distribution takes on a "normal" appearance. The accumulative probability plots, at first glance, indicates that the subject was in a learning mode for the first five trials. A closer examination of the data indicates that this can occur naturally as part of the statistical distribution.

The first three number of hits points are 7, 5, and 6 considering the first 75 points as the population with probability of success = .2936 (the final probability) then the expected value is 22 (using binomial distribution) and the variance is 15.55 (S.D=3.9). As a normal deviation from the mean (i.e., using normal distribution approximation  $P(x < 18) = .13$ ).

Although the observed learning can be rationalized as a natural statistical deviation it warranted further investigation. The plots of the accumulative probability of success for machine 1 and machine 2 are presented in Figure 2.5 and Figure 2.6. The plot for machine 1 (Figure 2.5) is a typical sinesoidal decreasing amplitude convergent curve. The plot for machine 2 however, is very suspicious in terms of learning. The major peaks of the curve (at approximately trial 10, 23, 40 and 56) are increasing which implies his probability of success is continuing to increase instead of converging on one point. Another interesting point ~~is~~ <sup>is that</sup> the points at which he switches onto machine 2 are 1, 9, and 36.

Also of concern is the sharp upward turn during the last 8 samples. The hits totals for this period, starting at sample 49 is 10, 10, 8, 11, 6, 8, 7, and 11 for a total of 71 hits out of a possible 200 for a probability of success of .36. Once again using the binomial distribution and using the probability of success of .29 (the cumulative probability up to the 49th point) the expected mean is 58 and the standard deviation 6.42. Using the



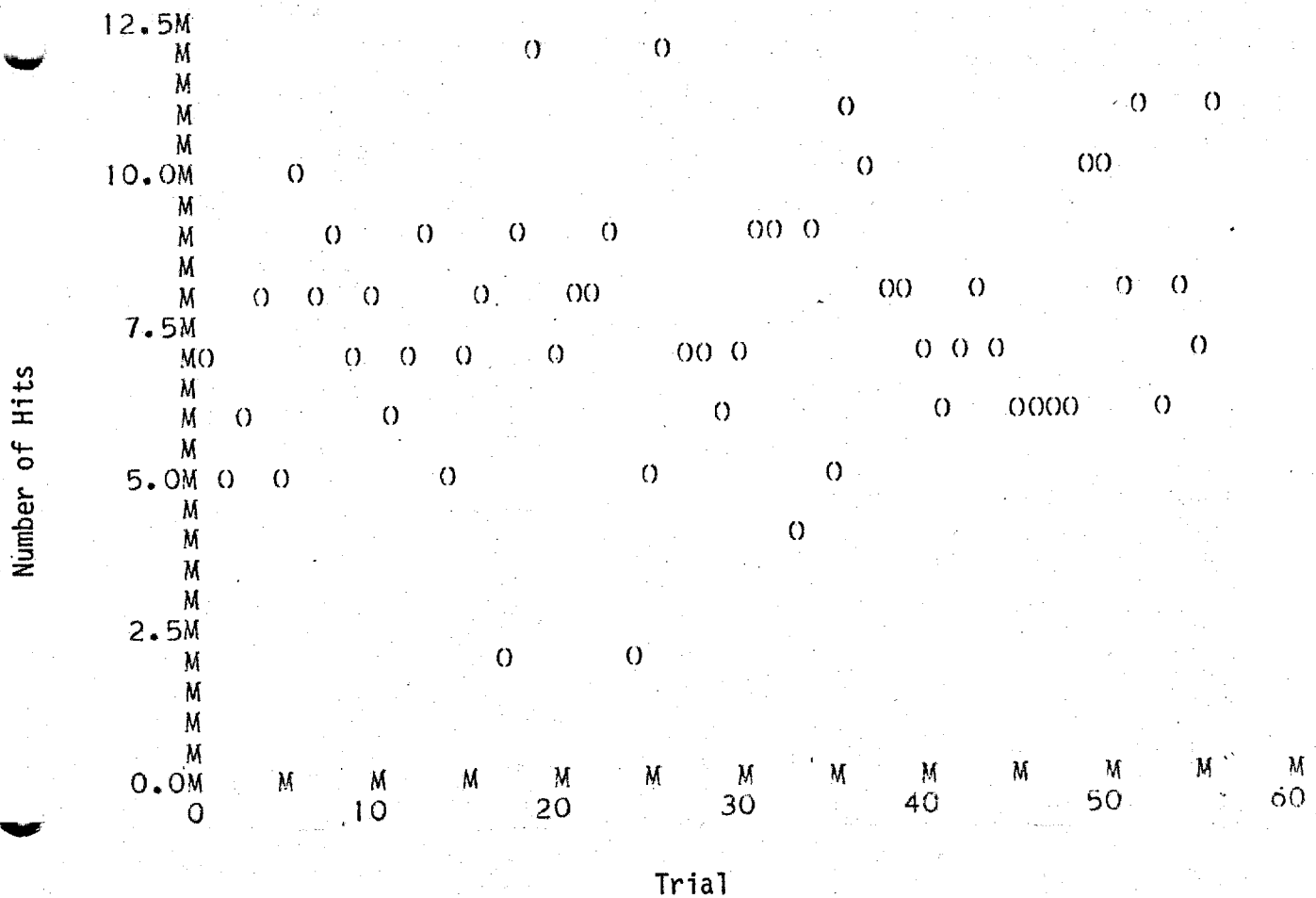


Figure 2.7 Plot of Number of Hits on Machine 1

normal approximation the probability  $P(X \geq 71) = .02$  of such an occurrence is quite low.

Although there are only 56 data points in this population and the apparent abnormalities are statistically possible (with low probability) this investigation concludes that the subject's learning for this case must be flagged as a real possibility. Figure 2.7 (Number of hits on Machine 1) has been added to provide clarity. It appears that the subject just didn't have "low hit" days toward the end.

#### Learning within a Trial

The question of learning within a trial or run has been investigated by summing the number of hits of the  $i$ th sample for the run. The results are somewhat distorted because of the inequitable distribution of passes. The lower numbered samples have significantly more hits because of this. *from both machines?* *2.5?* A plot of the number of hits per sample vs. sample number is shown in Figure 2-7.

Notice that the first sample has a value of 34 hits. This means that everytime he sits down for a new 25 sample trial he hits 34% of the time on his first try. With this in mind along with the rest of the data points, it is obvious that the subject doesn't learn throughout the trial.

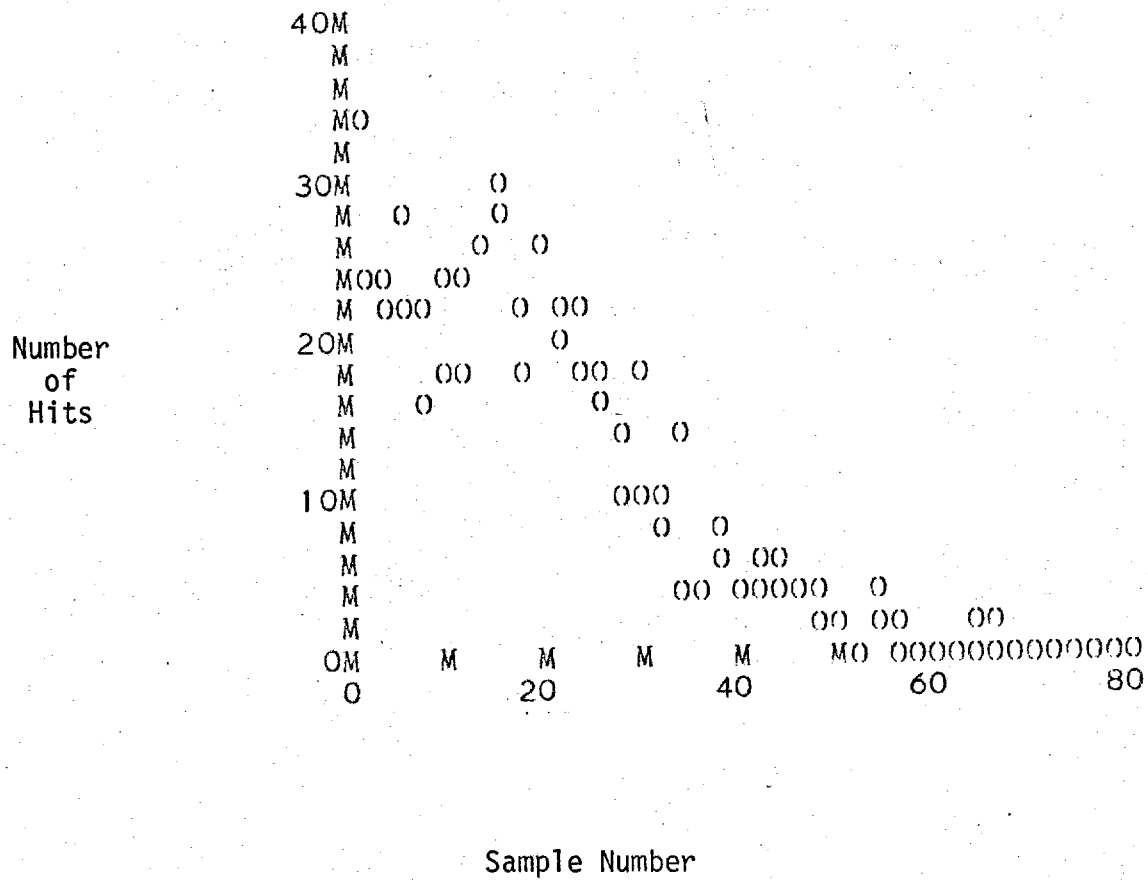


Figure 2.8 Total Number of Hits Within a Trial

Miscellaneous

Numerous arrays of data have been examined for the purpose of obtaining some insight into the data. Some of the data is being printed herein so that the data can be examined more closely if desired.

This first table is presented for use as a quick reference.

Day	Last Trial	Number of Tracks	Machine Used
1	8	8	2
2	16	8	1
3	24	8	2
4	36	12	2
5	44	8	2
6	52	8	1
7	56	4	1
8	64	8	1
9	68	4	1
10	72	4	1
11	76	4	1
12	80	4	1
13	84	4	2
14	88	4	2
15	100	12	2

The following displays are presented below with little commentary.

- I. General trial summary (Figure 3.1). Each trial (25 choices) is listed with the following information.
  - A. Machine used (1 or 2)
  - B. Total number of machine states in each color (i.e., 6 yellow, 6 green ....) for each trial.
  - C. Total number of subject choices for each color for each trial.
  - D. Total number of hits for each trial.
  - E. Total number of passes for each trial.
  - F. Breakdown of hits by color.
- II. Machine data for machine 1 and machine 2 separately (Figures 3.2, 3.3)

Just by examining these displays it may be possible to glean meaningful information. For example, machine 1 was used for the first 8 trials during which the first state of each trial was a yellow or red. If the first sample of each trial is most memorable, perhaps this is responsible for the subject's obvious preference of yellow and red (see Section 2 - Analysis of S2 Data Responses).
- III. Plots of the number of passes made.
  - A. Number of passes vs. trial number (i.e., trial is 25 or more samples) (Figure 3.4)
  - B. Number of passes vs. sample number (Figure 3.5)

trial	mach	mach yell	mach gren	mach blue	mach red	sub yel	sub grn	sub blu	sub red	numb hits	num pas	hit yel	hit grn	hit blu	hit red
1	2	6	6	2	11	11	3	5	6	7	0	3	0	0	4
2	2	5	9	4	7	10	3	4	8	5	0	2	1	0	2
3	2	7	8	6	4	7	4	6	8	6	0	2	2	1	1
4	2	7	4	10	4	10	3	4	8	8	0	4	1	2	1
5	2	5	6	11	3	11	4	0	10	5	0	2	1	0	2
6	2	8	5	3	9	10	3	2	10	10	0	3	1	0	6
7	2	3	7	7	8	11	1	3	10	8	0	2	0	2	4
8	2	6	7	3	9	11	2	2	10	9	0	4	1	0	4
9	1	9	6	2	8	10	3	5	7	7	0	4	0	0	3
10	1	5	5	8	7	9	6	1	9	9	0	3	3	0	3
11	1	6	4	7	8	6	6	3	10	2	0	0	0	0	2
12	1	7	2	7	9	9	5	3	8	6	0	4	0	0	2
13	1	5	7	4	9	10	3	2	10	12	0	3	2	1	6
14	1	4	5	11	5	10	2	2	11	8	0	2	1	2	3
15	1	6	9	5	5	10	3	1	11	9	0	3	2	0	4
16	1	6	2	7	10	8	5	4	8	5	0	2	0	0	3
17	2	10	12	7	7	12	2	1	10	7	11	4	0	0	3
18	2	4	9	9	11	10	2	2	11	8	8	1	1	1	5
19	2	8	9	10	11	11	3	2	9	6	13	3	0	1	2
20	2	7	13	5	8	11	1	4	9	7	8	3	1	1	2
21	2	9	8	9	9	10	5	1	9	9	10	3	2	0	4
22	2	13	12	9	9	8	2	2	13	5	18	0	0	1	4
23	2	9	9	15	12	11	1	2	11	7	20	2	0	1	4
24	2	10	9	11	9	8	3	2	12	8	14	3	2	0	3
25	2	3	11	7	8	8	5	5	7	2	4	1	0	1	0
26	2	10	4	10	10	8	6	4	7	9	9	4	0	2	3
27	2	11	6	15	9	11	1	0	13	12	16	6	1	0	5
28	2	5	6	10	11	10	5	2	8	7	7	2	1	1	3
29	2	7	16	16	14	8	4	3	10	8	28	1	2	1	4
30	2	16	19	18	12	8	6	1	10	8	40	3	3	0	2
31	2	10	10	9	19	10	5	1	9	9	23	2	1	1	5
32	2	12	9	19	12	8	7	3	7	2	27	2	0	0	0
33	2	11	14	20	10	9	4	2	10	5	30	2	1	1	1
34	2	16	4	10	8	9	5	3	8	12	13	5	2	1	4
35	2	9	7	11	15	12	4	3	6	7	17	3	0	2	2
36	2	14	17	19	22	9	4	1	11	7	47	2	1	0	4
37	2	5	16	13	11	9	5	2	9	6	20	0	4	0	2
38	2	5	7	8	9	7	8	2	8	7	4	1	3	0	3
39	2	7	7	9	6	6	6	3	10	9	4	1	3	1	4
40	2	11	13	10	10	7	6	2	10	9	19	2	4	0	3
41	2	10	14	9	12	4	8	2	11	4	20	1	1	0	2
42	2	11	11	7	9	4	7	3	11	9	13	2	3	0	4
43	2	15	13	14	11	4	9	3	9	5	28	0	4	0	1
44	2	10	9	11	8	8	6	4	7	11	13	4	1	4	2
45	1	12	9	7	8	10	6	2	7	8	11	5	1	1	1
46	1	5	6	9	7	4	4	6	11	6	2	0	0	2	4
47	1	9	10	10	4	8	6	2	9	6	8	3	2	0	1
48	1	9	10	7	6	8	3	4	10	6	7	2	1	1	2
49	1	7	10	6	2	4	6	6	9	7	0	0	5	1	1
50	1	9	12	1	7	9	3	4	9	6	4	3	0	0	3

trial	mach	mach yell	mach gren	mach blue	mach red	sub yel	sub grn	sub blu	sub red	numb hits	num pas	hit yel	hit grn	hit blu	hit red
51	1	6	5	10	8	6	5	6	8	9	4	2	2	3	2
52	1	7	15	11	9	8	5	1	11	8	17	3	2	0	3
53	1	11	5	7	6	9	3	3	10	6	4	3	1	1	1
54	1	6	4	7	12	9	5	1	10	9	4	2	2	0	5
55	1	13	14	12	14	8	4	1	12	7	28	0	2	0	5
56	1	12	14	19	14	12	2	2	9	6	34	3	0	1	2
57	1	8	2	11	8	9	3	2	11	8	4	3	0	1	4
58	1	6	4	11	12	8	2	3	12	6	8	1	0	1	4
59	1	11	5	15	6	4	3	2	16	8	12	2	1	1	4
60	1	11	11	11	11	5	2	2	16	8	19	3	0	1	4
61	1	10	8	9	8	8	4	0	13	8	10	0	1	0	7
62	1	13	6	9	10	7	1	0	17	7	13	3	0	0	4
63	1	10	18	10	7	6	1	2	16	4	20	2	0	0	2
64	1	10	11	6	9	10	0	2	13	8	11	4	0	0	4
65	1	7	9	2	8	4	4	5	12	8	1	1	1	1	5
66	1	3	12	4	7	8	9	2	6	8	1	3	4	0	1
67	1	8	10	10	8	11	2	2	10	8	11	3	1	0	4
68	1	10	4	5	9	13	2	1	9	7	3	4	0	0	3
69	1	10	8	4	8	10	4	2	9	9	5	4	1	0	4
70	1	9	6	12	17	8	6	2	9	4	19	0	2	0	2
71	1	11	7	7	8	5	7	1	12	7	8	2	1	0	4
72	1	7	9	13	9	8	7	0	10	3	13	1	1	0	1
73	1	11	6	5	10	10	4	5	6	9	7	4	1	2	2
74	1	4	12	8	8	8	4	4	9	6	7	0	2	1	3
75	1	9	11	7	8	5	8	1	11	7	10	1	3	0	3
76	1	8	14	5	6	4	6	4	11	10	8	2	4	1	3
77	1	11	3	8	6	12	2	0	11	9	3	7	0	0	2
78	1	9	9	10	11	9	3	1	12	6	14	3	0	0	3
79	1	7	8	7	12	9	4	2	10	7	9	2	2	0	3
80	1	8	6	10	8	14	1	2	8	8	7	4	0	1	3
81	2	13	4	8	5	12	2	3	8	10	5	7	1	0	2
82	2	6	14	10	11	11	0	2	12	8	16	2	0	1	5
83	2	7	10	17	16	13	1	0	11	8	25	3	0	0	5
84	2	14	12	16	14	12	0	0	13	7	31	3	0	0	4
85	2	7	7	10	7	9	6	4	6	6	6	2	2	1	1
86	2	11	7	4	6	12	6	1	6	7	3	5	1	0	1
87	2	13	13	9	6	17	1	2	5	8	16	5	1	2	0
88	2	6	3	8	9	14	3	4	4	7	1	4	1	1	1
89	2	6	5	8	6	8	5	2	10	6	0	2	1	1	2
90	2	7	7	4	7	7	7	4	7	6	0	1	3	1	1
91	2	9	10	7	2	7	6	2	10	6	3	4	1	1	0
92	2	4	6	10	5	8	6	3	8	6	0	1	3	1	1
93	2	6	7	7	7	7	5	3	10	10	2	3	2	1	4
94	2	5	6	4	13	7	6	2	10	10	3	3	1	1	5
95	2	7	5	10	11	7	6	0	12	8	8	2	1	0	5
96	2	7	9	7	9	11	4	0	10	11	7	5	1	0	5
97	2	8	8	6	5	8	4	4	9	6	2	2	1	1	2
98	2	7	12	10	5	9	5	2	9	8	9	3	3	0	2
99	2	8	9	8	8	7	6	2	10	7	8	2	2	0	3
100	2	9	5	9	10	12	5	0	8	11	8	5	3	0	3

Figure 3.1 (Continued)

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 112233022001200302031000123121033  
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1011021230212001120111200203

0232212112223203231310120

033231031211110302023012232

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0320102302131222201103111110312212

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Figure 3.3 Color states of machine 2 during the experiment

(0 yellow, 1 green, 2 blue, 3 red)

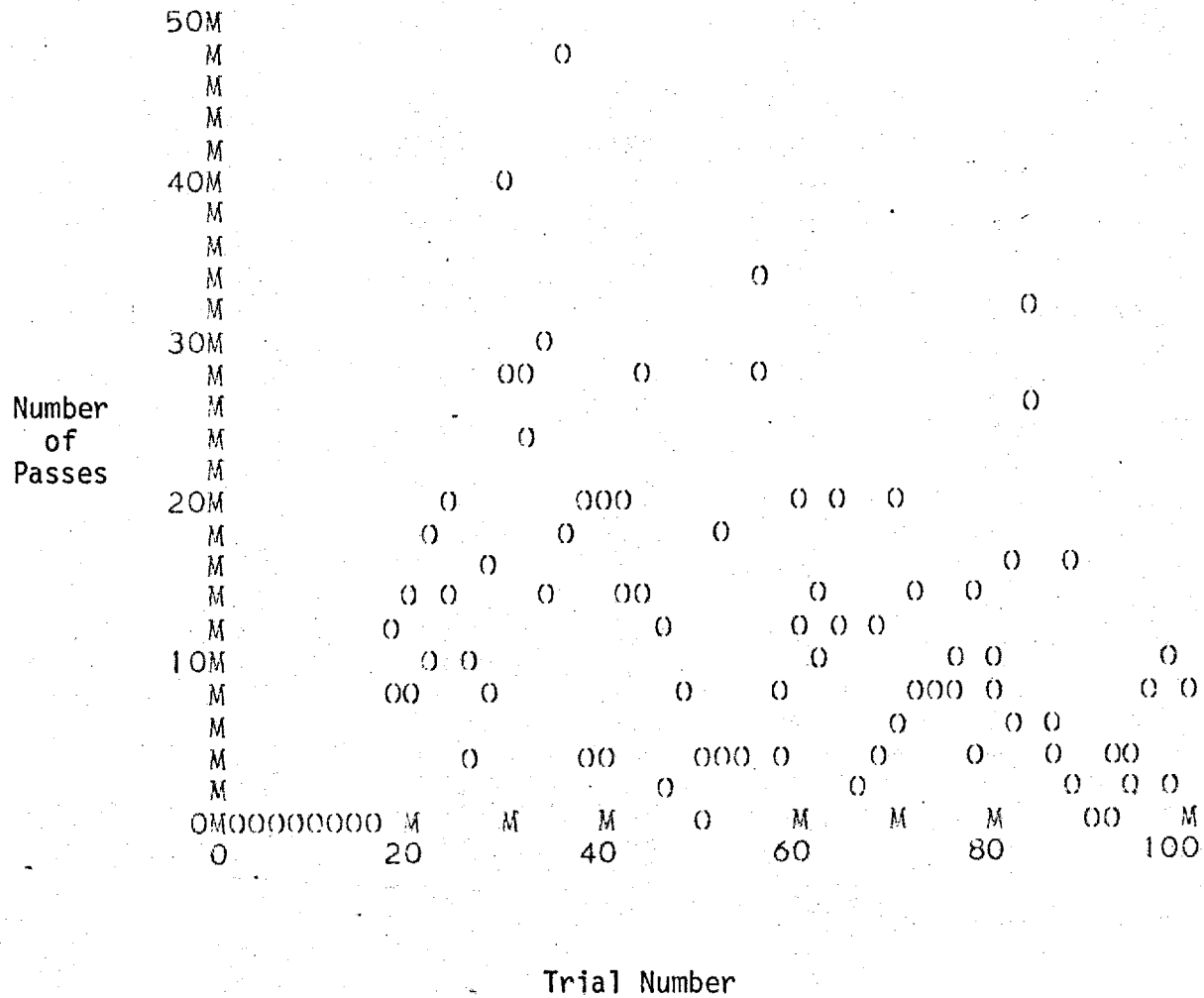


Figure 3.4 Total number of passes summed over a trial

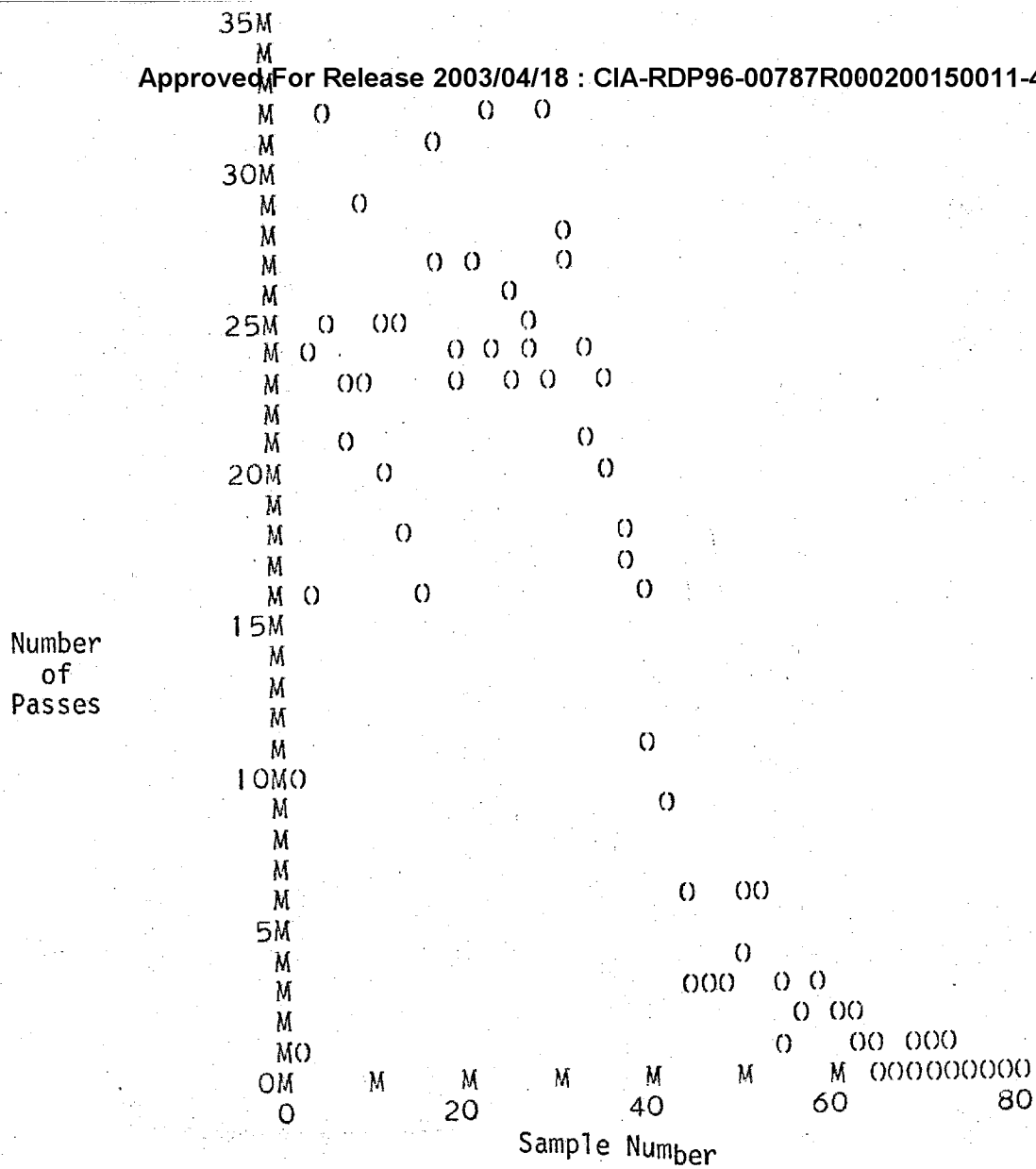
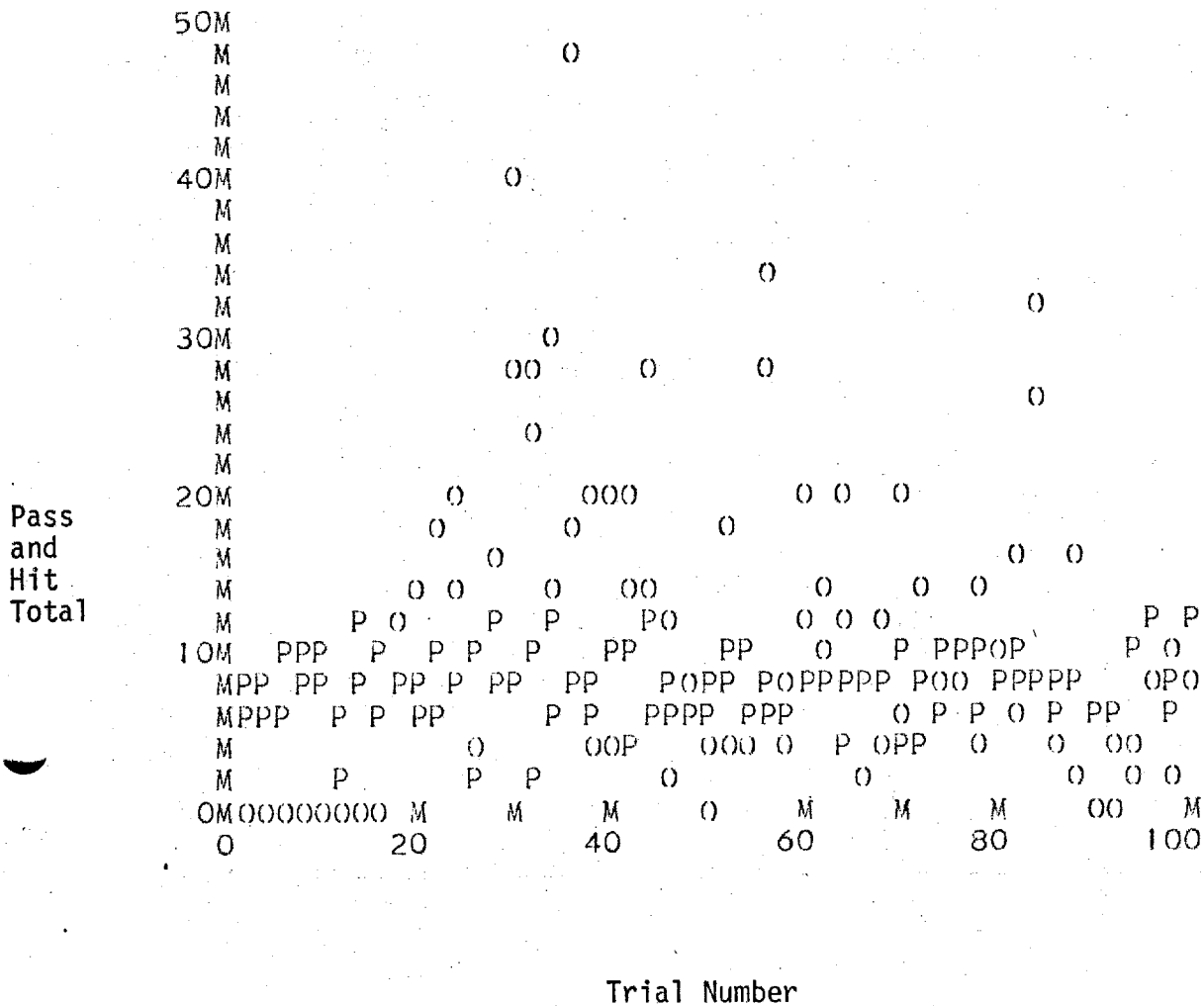


Figure 3.5 Total number of passes summed over sample number

- C. Number of passes and the number of hits vs. the trail number on one plot. Investigation of the hits/passes relationship was dropped when the coefficient of correlation between the two was computed at  $-.114$



O - passes per trial  
P - hits per trial

Figure 3.6 Plot of number of hits per trial and number of passes per trial

IV. Tables of state transitions which reflect the influence of the subject on the machine. For color choices of the subject the table shows the number of colors the machine has on the next sample. For example on the first table, when the subject picked yellow, on the next sample 197 times the machine state was yellow.

MACHINE STATES ON FOLLOWING SAMPLE				
	Yellow	Green	Blue	Red
Yellow	88	77	87	95
Green	38	46	39	47
Blue	27	28	24	24
Red	120	105	99	112
Pass	84	83	98	81
Machine 1				
Yellow	109	124	128	141
Green	58	47	58	66
Blue	25	32	42	30
Red	121	125	136	102
Pass	146	162	161	168
Machine 2				
Yellow	197	201	215	236
Green	96	93	97	113
Blue	52	60	66	54
Red	241	230	235	214
Pass	230	245	259	249
Both Machines				

Figure 3.7 State Transitions from Subject Choice to Future Machine State

V. Because of the possibility that the subject was learning the state of machine 2 the distribution of the colors are plotted in Figures 3.8, 3.9, 4.0, and 4.1. The only states used are those in which the subject didn't pass. Therefore there is a total of 25 for each trial.

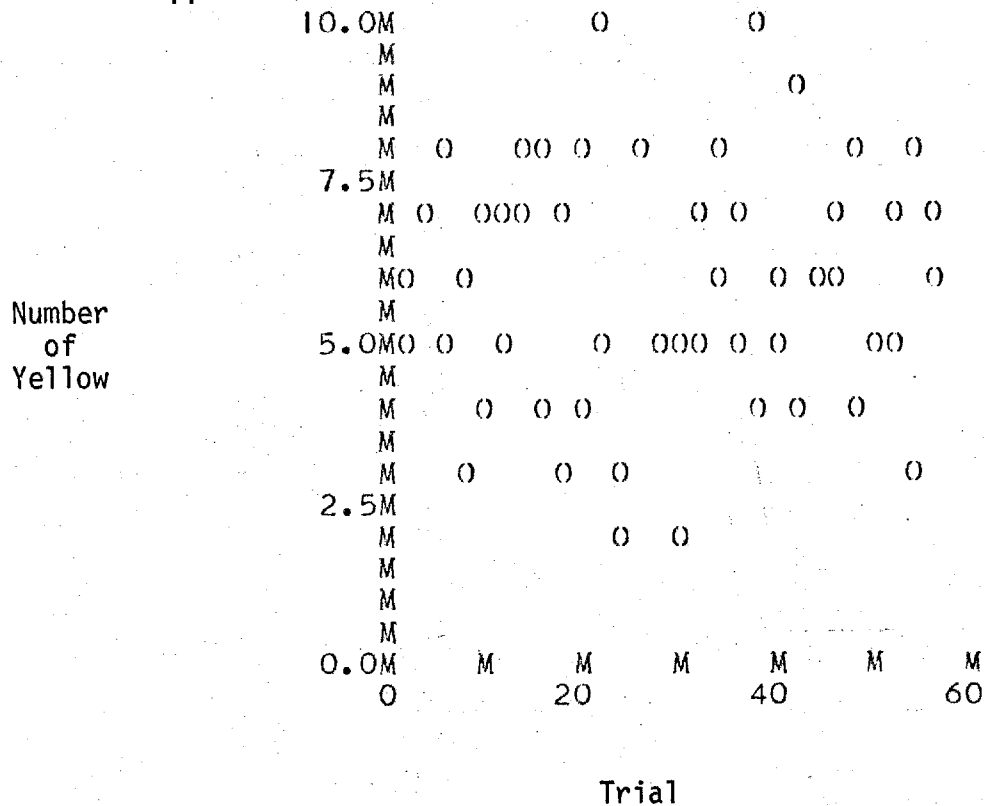
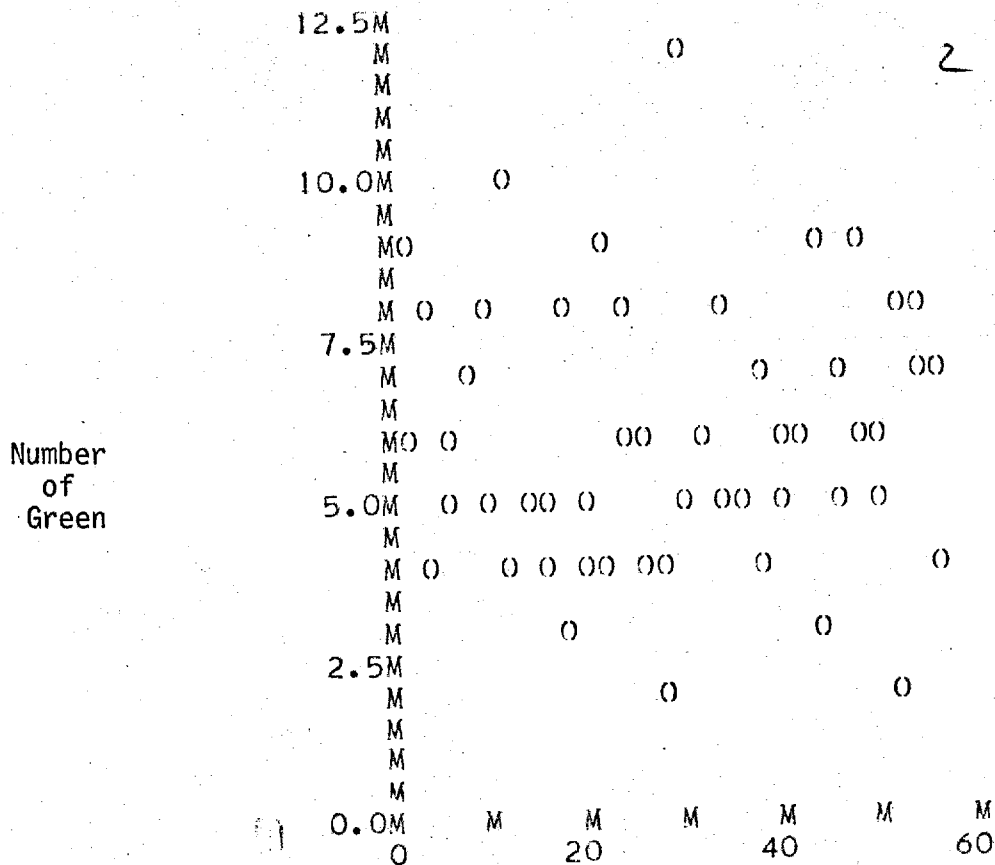
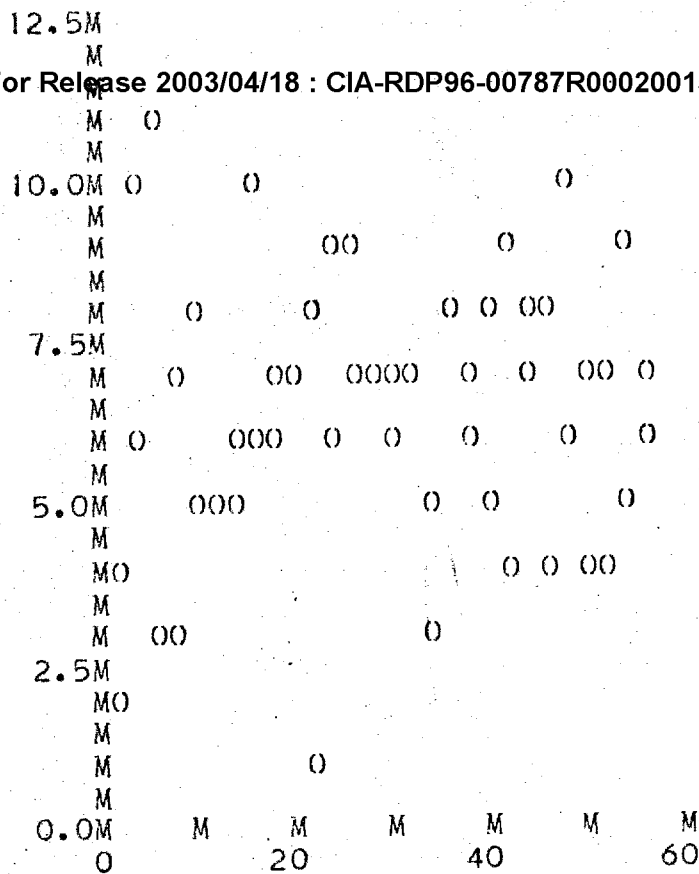


Figure 3.8 Distribution of Yellow for Machine 2





Number  
of  
Blue



Test	Description	Scoring					
		S1	S2	S3	S4	S5	S6
Halstead Category Test	Nonverbal test requiring abstraction of conceptual relationships. Score: Total errors.	7	14	33	26	6	28
Tactual Performance Test	Requires placement of 10 geometrically shaped blocks in their correct locations on a formboard while blindfolded. Separate RT, LT, and bimanual trials. Score: Total time (min.).	16.4	11.8	7.7	7.7	11.4	6.9
Speech Perception Test	Discrimination of non-word speech sounds. Score: Total errors.	4	2	0	2	5	3
Seashore Rhythm Test	Discrimination of nonverbal rhythms. Score: Number correct.	27	25	28	29	26	29
Finger Tapping Test	Measure of finger oscillation rate for 10-sec. period, both RT and LT hand trials. Score: No. taps/10 sec.	RT/LT 53/50	RT/LT 53/49	RT/LT 48/47	RT/LT 54/53	RT/LT 47/47	RT/LT 48/43
Trail Making Test (Part A)	Requires connecting numbered circles in order from 1 to 25. Paper and pencil task. Score: Total times (sec)	40	16	18	19	30	27
Trail Making Test (Part B)	Requires connecting alphabetic and numbered circles by alternating 1→A→2→B, etc. Score: Total time (sec)	56	50	55	50	54	53
Knox Cube Test	Measure of attention span and immediate visual memory. Score: Number correct.	13	14	13	16	17	17
Raven Progressive Matrices	Nonverbal intelligence test involving spatial matrices. Score: Number correct.	39	53	49	55	60	54
Verbal Concept Attainment Test	Requires abstraction of verbal conceptual relationships. Score: Number correct.	22	24	27	23	21	24
Buschke Memory Test	Requires learning a 20-word list in a maximum of 12 trials with repetition of words omitted after each trial. Score: Max. no. words correctly remembered; List: no. words consistently remembered	Total: 14/20 List: 8/20	17/20 14/20	18/20 11/20	19/20 16/20	20/20 15/20 (8 trials)	20/20 16/20 (7 trials)
Grooved Pegboard Test	Requires insertion of 25 pegs in their holes in a pegboard. Both RT and LT hand trials. Score: Total time (sec).	RT/LT 76/74	RT/LT 69/70	RT/LT 58/67	RT/LT 59/67	RT/LT <del>70/70</del> 72/70	RT/LT 48/50
Spatial Relations Subtest of the PMA	Requires mental rotation and identification of figures rotated in 2 dimensions. Score: no. correct - no. errors.	-	-	-	-	60	52
Gottschaldt Hidden Figures Test	Requires tracing outline of simple figure hidden within lines of more complex figure. Score: time and no. correct.	Poor	Avg.	-	v. good	outst.	outst.